The Evolution of Aeronautical Research - from Principles to Operations

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Outline

- Development of aeronautical research

- The step towards operations
  - **Impact of technologies** on operational performance
  - **Boundaries** for Future Developments
  - A **Change of focus**
  - Trade Off between **Mobility and Green Transportation**
  - A Customer in the Air Transportation System – Who is it?
  - A **Customer Perspective** – The Airline
  - Overall **Operations Oriented** Integrated Aircraft **Design**
  - **Efficient Production** – a key for future prosperous air transportation
  - **Integrated Information** Systems
  - **Climate** Optimized Air Transportation
  - **Laminar Flow** Technologies in Operations

- **Future Objectives** of Aeronautical Research

Development of Aeronautical Research

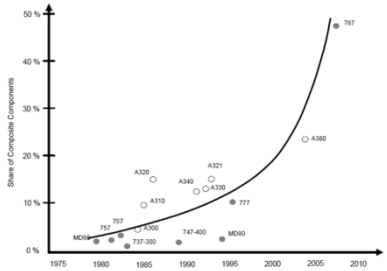
Aeronautical disciplinary research on aircraft has reached a very high level of maturity during the past decades

Focke-Wulf Fw 200, 1937

Airbus A380, 2003

From 26 pax, 1700km range to 550 **pax**, 15000km **range**

Junkers F13, 1919



From first full **metallic** aircraft to more than 50% **composite** aircraft

Boeing B787, 2012

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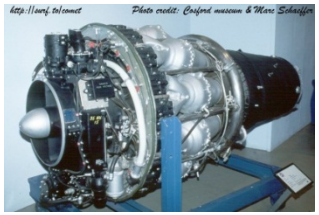
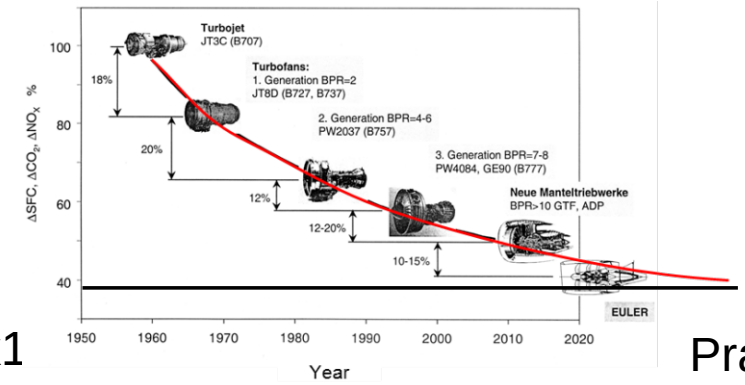
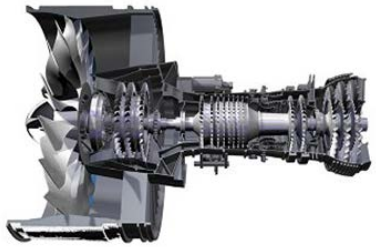


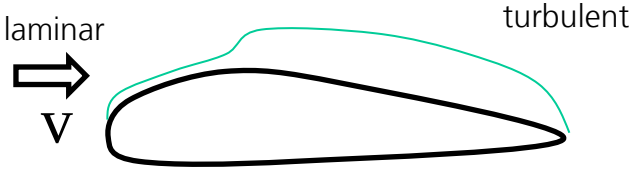
De Havilland Ghost Mk1

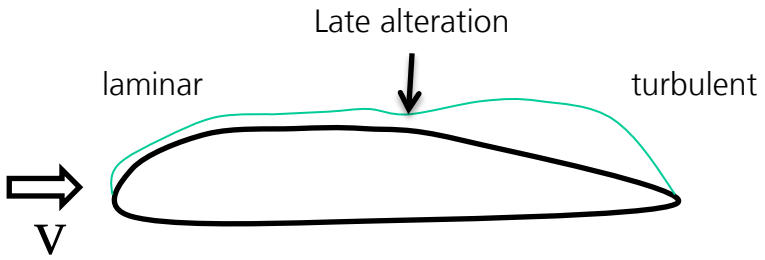




Pratt & Whitney, PW1400

From zero bypass to high **bypass** (12:1) engines





From turbulent flow profiles to **laminar flow** profiles

Development of Aeronautical Research

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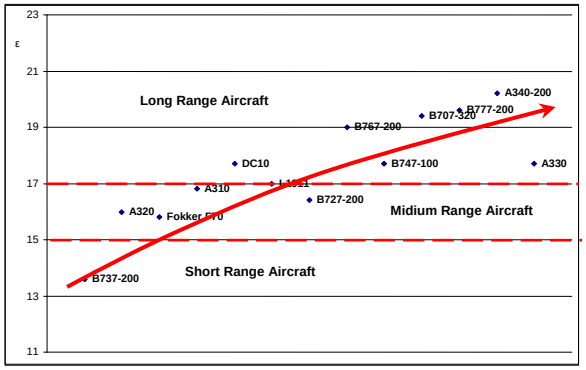
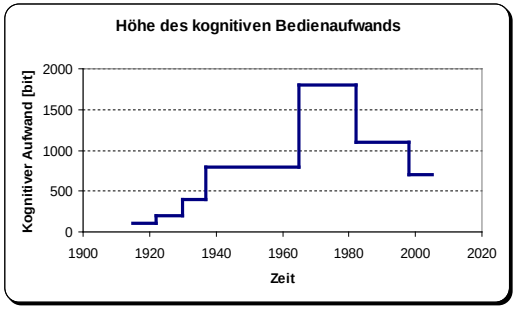
Focke-Wulf Fw 200, 1937



Boeing B787, 2012

From low L/D ratio (~9) to **high L/D ratio** (21, CL=0,508, CD=0,0459) aerodynamic performance

Concorde, 1969

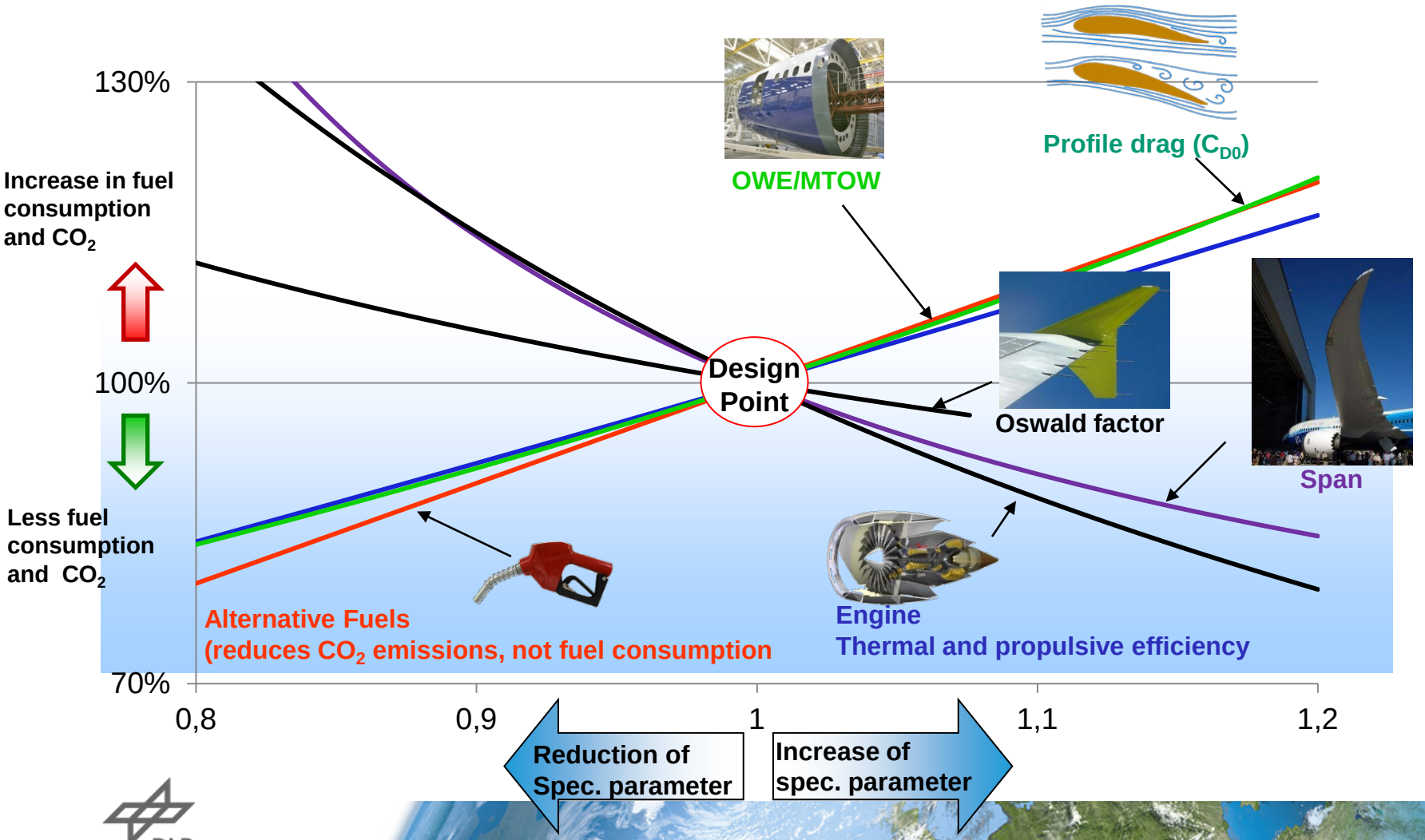


Boeing B787, 2012

From single analogue to **highly integrated avionics** systems to reduce pilot information load

The Step towards Operations

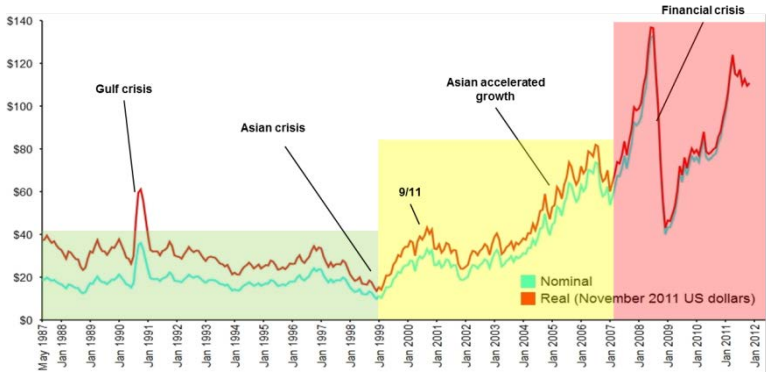
Impact of technologies on operational performance



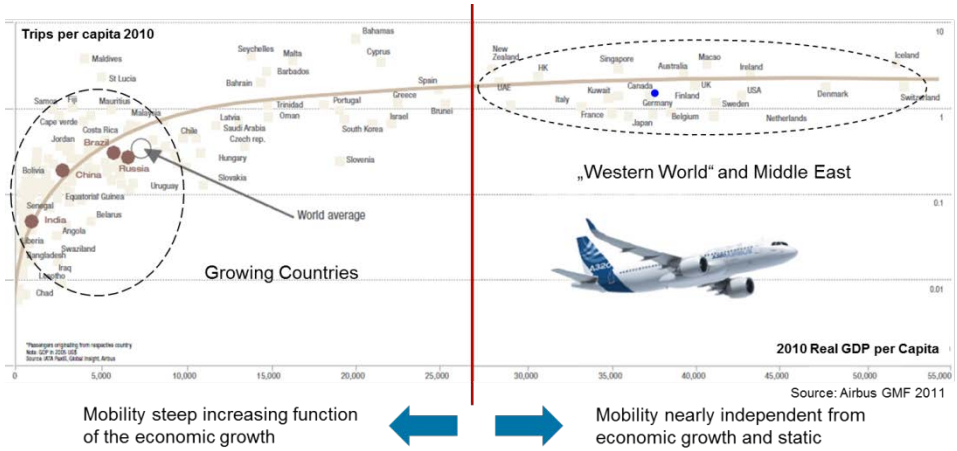
The Step towards Operations

Boundaries for future developments

Oil Price Development



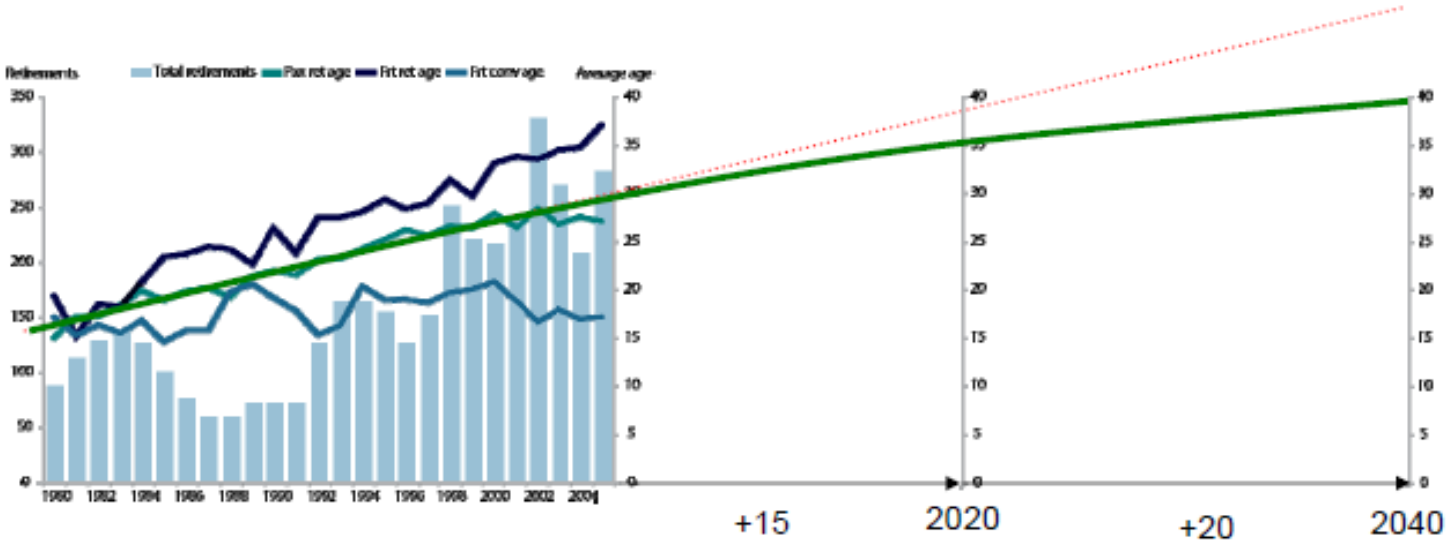
Development of Mobility



Developing **energy cost** and **saturating demand for mobility** will limit quantitative growth

The Step towards Operations

Boundaries for future developments



Average **age of aircraft** is continiously **increasing** towards 40 years of individual A/C operation

Thus **money** can only be made with short life time components like **cabin, avionics, software, cabin electronics** which are to be replaced every few years

The Step towards Operations

Boundaries for future developments

Individual

Super sonic business jet

No new aircraft within the next 25 years!!!

Lon Range

Airbus A380

Airbus A350

Boeing 787

New Long Range

New Macro Body

Hydrogen as prime fuel?

Short & Midium Range

Boeing 737MAX

UAC

Airbus A319neo

COMAC

Boeing 737+

Airbus A30x

2010ties → 2020ties → 2030ties → 2040ties → 2050ties

DLR

The Step towards Operations

Boundaries for future developments

The **„Rebound“** Effect:

- **Weight savings are consumed** by additional equipment

- **Individual** of aircraft fuel consumption **savings** through aerodynamics, propulsion and weight are **consumed by massive increase in world aircraft fleet**

The Step towards Operations

A change of focus

- Most **physical principles** of aircraft design disciplines are **well understood**
- Only **minor incremental improvements** are further achievable with significant effort
- During the next at least 20 years **no new aircraft** are to be expected due to the great success of the current products like A320NEO, B737Max, A350, B787
- Aviation is facing **more competition** with other transportation systems
- Stakeholder expectations (passenger, are more and more addressing **quality, efficiency and environmental compatibility of the entire transportation chain**
- Due to high economic and ecological pressure **efficient operation** of aircraft is a key for success of aviation

The aircraft is no longer in the main focus

Overall chains from production to operation become more relevant and **key success factor**

The Step towards Operations

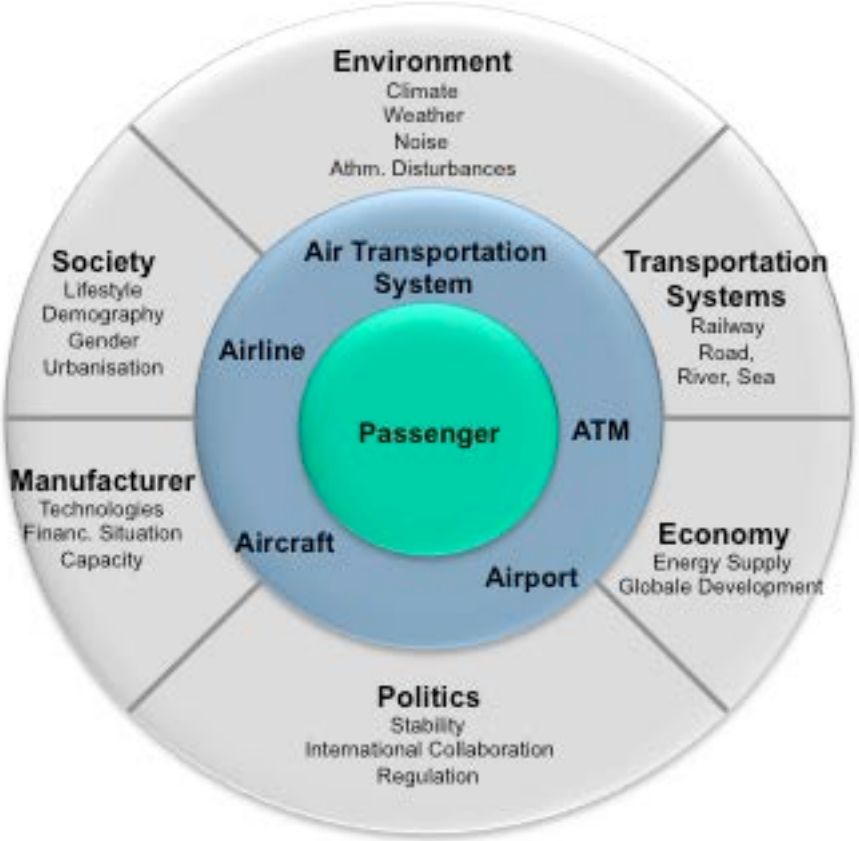
Trade Off between Mobility and Green Transportation

- An increasing demand for **Mobility as a major pillar** of prosperity
- Increasing energy/oil cost and ecological responsibility **argue against quantitative traffic growth**
- Ensure **mobility with less energy effort**, emissions and noise, **requests for less traffic ➔ less aircraft, less airport, airspace capacity**
- **Passenger mobility** can be achieved with **less aircraft movements**
- **Cost and emissions** per flight are **to be shared** by more people per trip

➔ Paradigm shift from quantitative air transport growth to qualitative air transport growth

Source: U. Becker, TU Dresden, V. Gollnick, DLR

The Step towards Operations



- **Optimization and Quality** are mainly addressing **partial** areas of the entire transportation chain
- VISION2020 and FLIGHTPATH2050 are setting **extreme and holistic challenges**
- Air Transportation faces **increasing social concerns**
- Stakeholder/customer are more **demanding**
- Are passengers the only **customer**?

The Step forward to Operations

A Customer in the Air Transportation System – Who is it?

Customer	Service Provider
Aircraft Manufacturer	**System Supplier**
Airline	Aircraft Manufacturer
Airline	**MRO**
Airline	**Air Navigation Service Provider**
Airport	Air Navigation Service Provider
Airline	Airport
Airport	**Ground Services**
Airline	Ground Services
Passenger	Airline
Passenger	Airport
Passenger	**Retail**
Retail	Airport
	…

Role Change Customer – Service Provider
Service Provider

- Many provider are customer as well
- Each service provider is optimizing himself to fulfil specific customer expectations in his area…

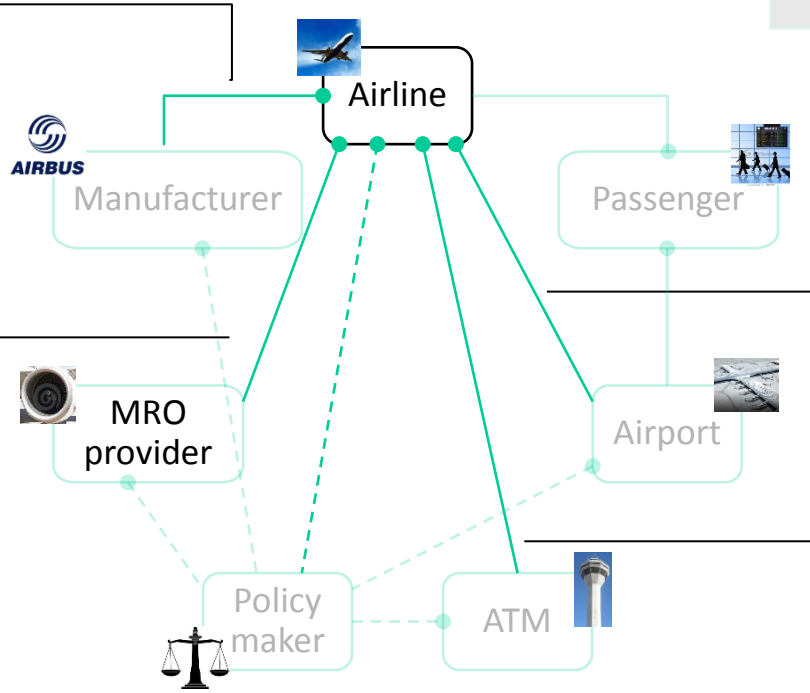
The Step forward to Operations

A Customer Perspective – The Airline

Overall travel Expectation :
- Connectivity
- Travel times
- Comfort
- Predictability
- Fluency

A — B A is customer of B

- Efficient aircraft (low SFC, low **emissions**, low **MRO**)
- Low acquisition costs
- Available as required



- Sufficient **capacity** (slots, gates)
- Low fees
- Low **turnaround**-times
- Low transfer times

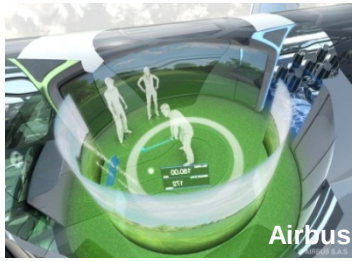
- Low costs
- High reliability
- High **utilization**
- High availability

- Sufficient capacity
- **No detours**
- Low fees

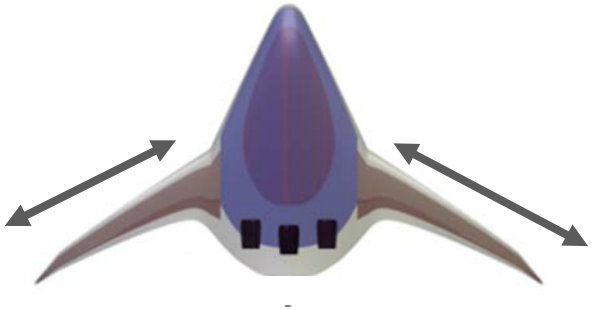
Process improvements increase customer satisfaction!

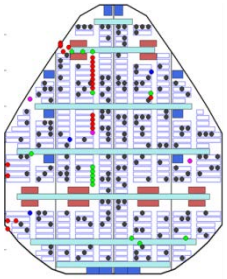
The Step towards Operations

Overall Operations Oriented Integrated Aircraft Design

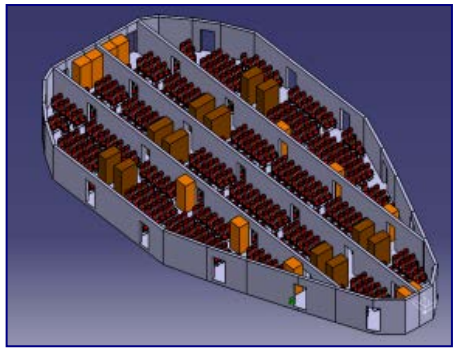


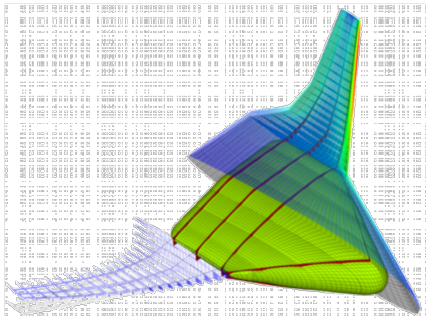
Cabin Design



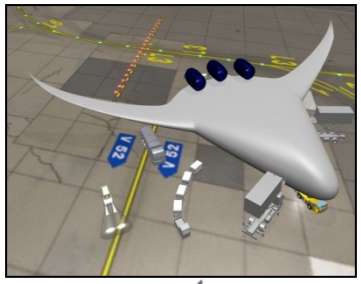


Boarding





Turnaround Operations



Source: DLR, Institute for Air Transportation Systems

DLR

The Step towards Operations

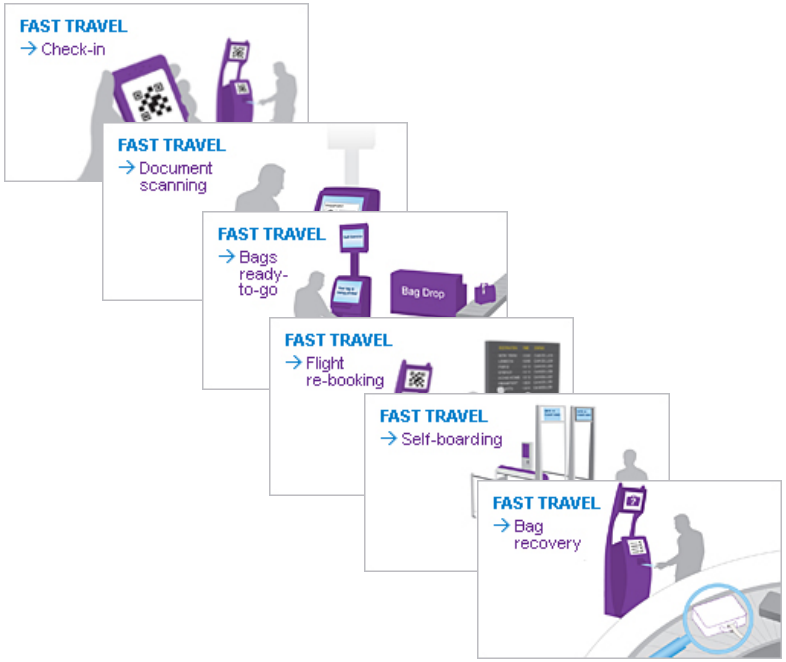
Efficient Production – a key for future prosperous air transportation

Production and assembly of high quality large integrated components

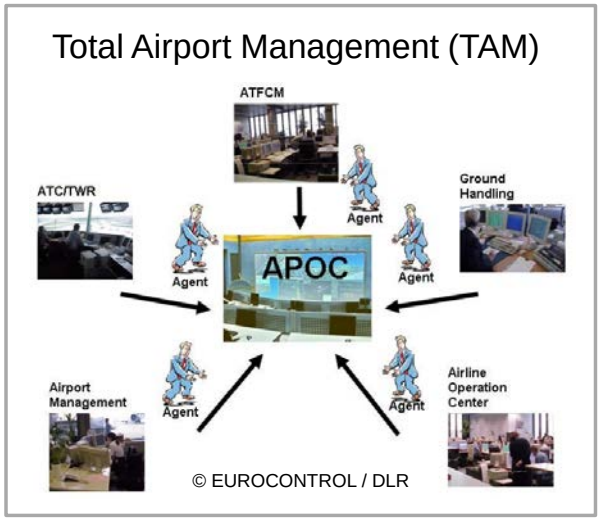
Automated production and assembly of fuselage and cabin

The Step towards Operations

Integrated information exchange



Passenger Services and Flow



Total Airport Management

Communication and Software Technologies are key for efficient production and operations

-SITA Airline IT trends 2008

The Step towards Operations

Climate Optimized ATS – Trade Off between DOC and climate impact

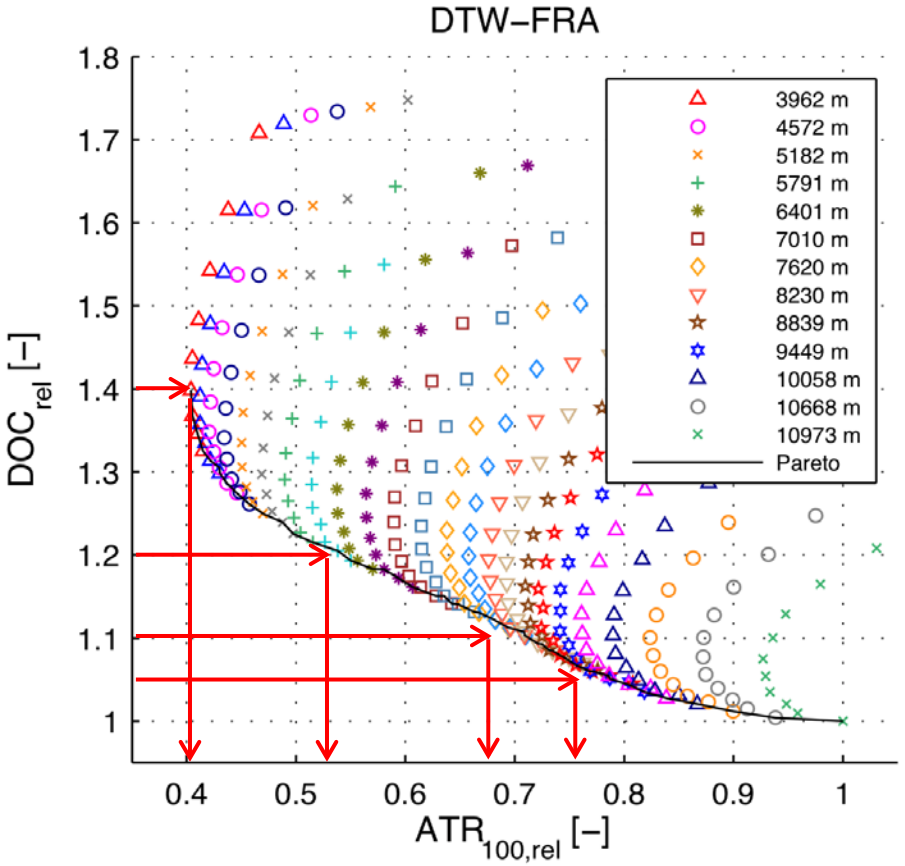
- Trade-off for exemplary mission depicted (-> Pareto frontier)
- Mission: DTW-FRA
- Climate impact reduction of

  59 %

  requires

  40 %

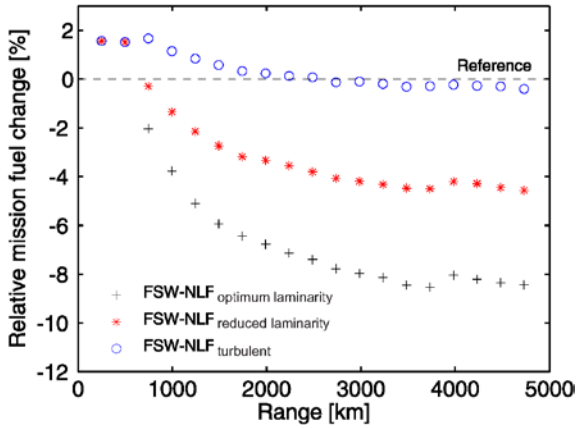
  DOC increase wrt. minimum DOC operations!
- Identification of ideal trade-off for whole route network allows for the derivation of a new design point for a more climate-friendly aircraft

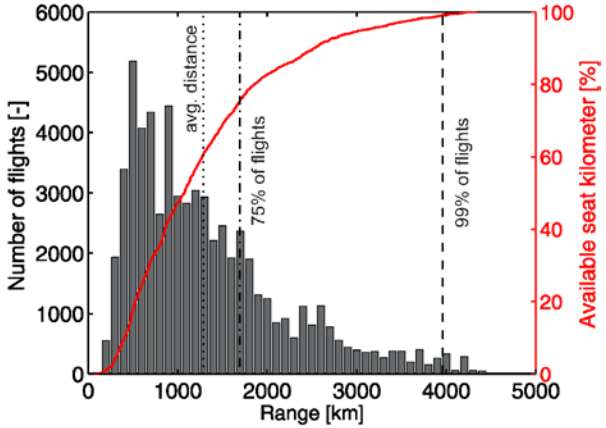


The Step towards Operations

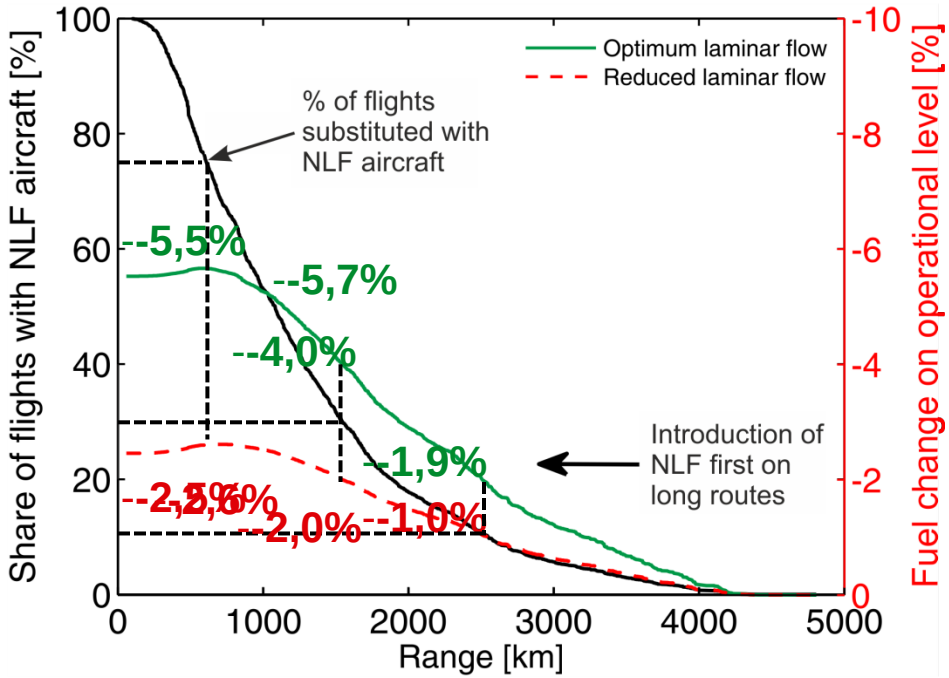
Laminar Flow Technologies in Operations

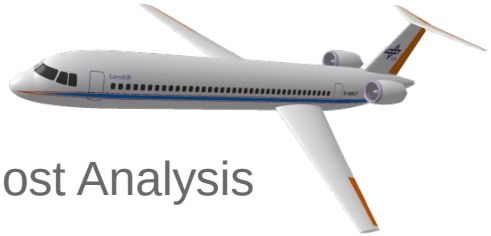
Single Mission Operation vs. Fleet Operation





Fuel saving on operational level





The Step towards Operations

Laminar Flow Technologies in Operations – Life Cycle Cost Analysis

Airline Life Cycle Cost-Benefit Model **AirTOBS**
Modeling all cost, revenues, and utilization of aircraft operations
Superior to standard DOC-methods

(a) Cash flow results

Main assumptions:

Fuel price at 80 $/barrel, same aircraft list price and maintenance cost.

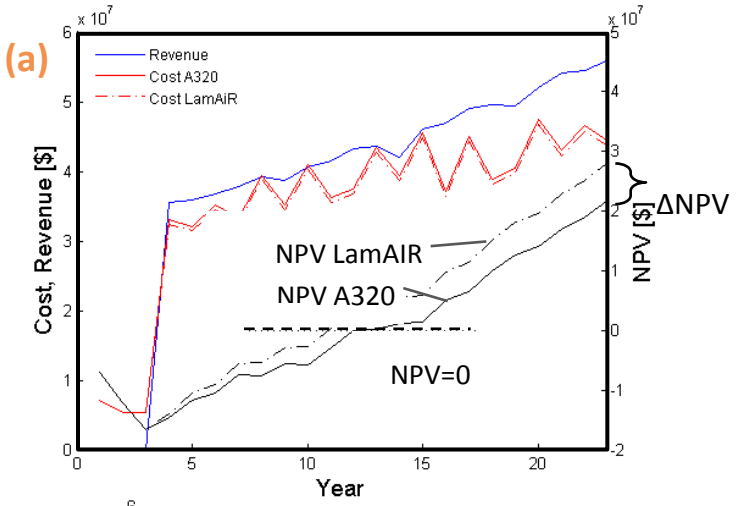
(b) Fuel price variation for ΔNPV

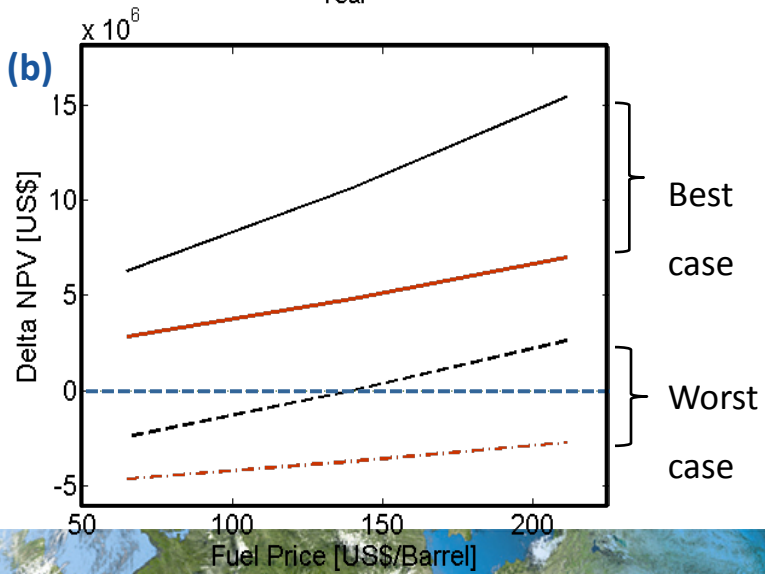
For design range and representative range distribution

Assumptions:

—— *Best case*: +20$/FC maint.; same A/C list price

- - - *Worst case*: +500$/FC maint.; +5% A/C list price





The Step towards Operations

Future Objectives for Aeronautical Research

Operational Issues of Future Aernautical Research:

Comfort

Travel time

Capacity

Maintenance

Security

Emissions

Noise

Production

Recycling

In a world of growing energy cost, increasing A/C life time, saturating mobility:

It´s **operations** rather than physical technologies, which drives the success of **future qualitative growth of air transportation**!

Thank you for your interest!

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